

SHOT SLEEVE ASSEMBLY WITH MATERIALS OF DIFFERENT COEFFICIENTS OF THERMAL EXPANSION

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0001] This subject of this disclosure was made with support from the Singapore government.

BACKGROUND

[0002] This disclosure is generally directed to a shot sleeve for a die casting process. More specifically, this disclosure is generally directed to a shot sleeve formed of different materials.

[0003] A die casting process utilizes a mold cavity defined between mold parts. Molten metal material is feed in to the cavity and held under pressure until the metal hardens. The mold parts are then separated and the cast part removed. In some processes a shot sleeve is utilized to hold molten material and introduce that material to the cavity. The shot sleeve includes an opening for introducing molten material into a bore that leads to the cavity. A plunger moves within the bore to inject the molten material into the cavity. The plunger is subsequently withdrawn and additional material is introduced into the plunger for fabricating another part within the same cavity.

[0004] The shot sleeve experiences the very high temperatures of the molten metal material and therefore is fabricated of materials compatible with those high temperatures. However, materials that are compatible with the high temperatures encountered during the die casting process can be costly and difficult to machine. Accordingly, it is desirable to design and develop shot sleeves that can withstand the high temperatures while reducing cost and easing manufacturing.

SUMMARY

[0005] A shot sleeve assembly for a die casting process according to an exemplary embodiment of this disclosure, among other possible things includes a housing defining a bore open at both a front end and a rear end and a pour opening for receiving molten material. The housing includes a material of a first coefficient of thermal expansion, a core received within the bore and extending from the front end to the rear end including a

core opening aligned with the pour opening. The core including a material of a second coefficient of thermal expansion lower than the first coefficient of thermal expansion, a front cover attached to the front end of the housing, and a rear cover attached to the rear end of the housing, the rear cover forcing the core against the front cover holding the core within the bore of the housing.

[0006] In a further embodiment of the foregoing shot sleeve assembly, the rear cover includes a nut threadingly received within the bore and rotatable to force the core against the front cover.

[0007] In a further embodiment of any of the foregoing shot sleeve assemblies, the housing includes flats for holding rotation of the housing responsive to rotation of the rear cover.

[0008] In a further embodiment of any of the foregoing shot sleeve assemblies, the front cover includes a shoulder against which the core abuts for holding the core within the bore.

[0009] In a further embodiment of any of the foregoing shot sleeve assemblies, includes a plurality of fasteners extending through the front cover for securing the front cover to the front end of the housing.

[0010] In a further embodiment of any of the foregoing shot sleeve assemblies, the front cover includes a plurality of threaded openings for receiving corresponding threaded fasteners for forcing the front cover from the housing.

[0011] In a further embodiment of any of the foregoing shot sleeve assemblies, includes a key member disposed between the housing and the core for holding a position of the core relative to the housing.

[0012] In a further embodiment of any of the foregoing shot sleeve assemblies, the core is fabricated from a refractory metal material.

[0013] In a further embodiment of any of the foregoing shot sleeve assemblies, the core is fabricated from a ceramic material.

[0014] A method of casting a cast article according to an exemplary embodiment of this disclosure, among other possible things includes defining a mold cavity between at least two mold parts, mounting a shot sleeve, heating a shot sleeve to a pre-heat temperature, tightening a rear cover threadingly received within a housing to force a core disposed within the housing into a front cover, pouring a quantity of molten material into the core through a

pour opening in the housing, forcing the molten material into the mold cavity, and curing the molten material within the mold cavity.

[0015] In a further embodiment of the foregoing method of casting a cast article as recited in claim 10, includes loosening the rear cover prior to cooling the shot sleeve to room temperature that is less than the pre-heat temperature.

[0016] In a further embodiment of any of the foregoing methods of casting a cast article, includes removing the front cover by inserting at least one threaded fastener through a threaded opening and threading the at least one fastener through the front cover and into engagement with a front end of the housing and forcing the front cover away from the housing by extending the threaded fastener from the front cover.

[0017] In a further embodiment of any of the foregoing methods of casting a cast article, the core has a lower coefficient of thermal expansion than the housing.

[0018] In a further embodiment of any of the foregoing methods of casting a cast article, includes extending a key through the housing against the core for preventing relative rotation between the core and the housing.

[0019] A casting assembly according to an exemplary embodiment of this disclosure, among other possible things includes a mold includes at least one cavity for receiving molten material, and a shot sleeve mounted to the mold for injecting molten material into the cavity. The shot sleeve includes a housing defining a bore open at both a front end and a rear end and a pour opening for receiving molten material. The housing includes a material of a first coefficient of thermal expansion. A core received within the bore and extending from the front end to the rear end includes a core opening aligned with the pour opening. The core includes a material of a second coefficient of thermal expansion lower than the first coefficient of thermal expansion. A front cover attached to the front end of the housing, and a rear cover attached to the rear end of the housing. The rear cover forces the core against the front cover holding the core within the bore of the housing, and a plunger movable through the bore of the shot sleeve for forcing molten material through the core and into the at least one cavity.

[0020] In a further embodiment of the foregoing casting assembly, the rear cover includes a nut threadingly received within the bore and rotatable to force the core against the front cover.

[0021] In a further embodiment of any of the foregoing casting assemblies, the front cover includes a shoulder against which the core abuts for holding the core within the bore.

[0022] In a further embodiment of any of the foregoing casting assemblies, includes a key member disposed between the housing and the core for holding a position of the core relative to the housing.

[0023] Although the different examples have the specific components shown in the illustrations, embodiments of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[0024] These and other features disclosed herein can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Figure 1 is a schematic view an example mold assembly.

[0026] Figure 2 is a cross-section of an example shot sleeve.

[0027] Figure 3 is a perspective view of the example shot sleeve.

[0028] Figure 4 is a rear perspective view of the example shot sleeve.

[0029] Figure 5 is a schematic view of a method of utilizing the example shot sleeve.

DETAILED DESCRIPTION

[0030] Figure 1 schematically illustrates an example mold assembly 10 that includes a mold 12 having a first part 14 and a second part 16 that defines a cavity 18. The example mold 12 includes an opening 20 that receives a shot sleeve 22. The example shot sleeve 22 defines a bore 34 through which molten material 26 is injected into the cavity 18. A plunger 24 is movable within the bore 34 to inject the molten material 26 into the cavity 18. The molten material 26 is of a temperature in excess of 2000 °F (1093 °C). Accordingly, the material comprising the shot sleeve 22 must be compatible with the excessive temperatures of the molten material 26.

[0031] Referring to Figures 2, 3 and 4, the example shot sleeve 22 includes a housing 28 with a front end 30 and a rear end 32. The bore 34 is disposed about a longitudinal axis 15 and extends from the front end 30 to the rear end 32. The bore 34 is

opened at both the front and rear ends 30, 32. The housing 28 is comprised of common steel and/or alloys of steel with a coefficient of thermal expansion that causes significant thermal growth during operation. Moreover, it is not desirable to provide direct contact between the housing 28 and the molten material 26 within the bore 34.

[0032] A core 42 fabricated from a material with a much lower coefficient of thermal expansion than steel is provided to define the internal surfaces in direct contact with the molten material 26. The core 42 is received within the bore 34 and provides an interior surface capable of withstanding the temperatures of the molten material 26 that can exceed 2000° F (1093 °C).

[0033] The example core 42 is comprised of a refractory metal material such as Anviloy or TZM. The core 42 may also be comprised of a ceramic material such as silicon nitride or silicon carbide that have low coefficients of thermal expansion. As appreciated, other high temperature compatible materials may be used and are within the contemplation of this disclosure.

[0034] Although a low coefficient of thermal expansion is desirable, the shot sleeve assembly 22 must also be of a sufficient strength and thickness to withstand and prevent the shot sleeve 22 from bending upwards due to encountering the temperatures of the molten material. Molten material is poured (Figure 1) through an opening 36 defined in the housing 44 that is aligned with an opening 52 within the core 42. Molten material therefore sits on a bottom surface 66 of the core 42 prior to being injected into the cavity 18. Because the molten material 26 sits on the bottom surface 66 of the core 42, the bottom portion of the housing 28 and the core 42 are heated more than the top surface and will expand more than the top portion causing the shot sleeve 22 to bend upwardly. The example housing 28 is of a sufficient thickness to overcome the upward bending caused by the differential temperatures between the bottom and top surfaces while also including the thinner core 42 that withstands the higher temperatures.

[0035] The example shot sleeve 22 includes a front cover 44 that is attached to the housing 28 with a plurality of fasteners 56. The example fasteners 56 are machine screws that extend through openings in the front cover 44 into threaded holes defined in the front end 30 of the housing 28. The front cover 44 is fabricated from a material determined to withstand the impact and wear encountered due to interaction with the mold assembly 10.

[0036] The front cover 44 is a separate piece from the housing 28 and thereby may be removed and replaced without having to replace the entire housing 28. The core 42 is

fit within the bore 34 of the housing 28 such that it may be removed and replaced due to wear and if damaged without replacing the entire shot assembly 22.

[0037] The front cover 44 further includes threaded openings 58 that receive fasteners that extend through to engage the front surface 30 of the housing 28. As appreciated, the fasteners 56 extend through clearance openings within the front cover 44 and are received within internally threaded openings in the housing 28. In contrast, the openings 58 are threaded such that a fastener extending through the openings will abut the end surface 30 and upon further tightening, drive the front cover 44 away from the front end 30 of the housing 28. In this way, the front cover 44 can be removed even if expansion or residual molten material makes it difficult to remove. The example front cover 44 also includes a shoulder 68 against which the core 42 abuts.

[0038] A rear cover 46 is threadingly received within the bore 34 of the housing 28. The rear cover 46 includes a threaded portion 48 that extends about the circumference of the core 42 and engages a threaded portion defined within the housing 28. The rear cover 46 also defines an opening 50 through which the plunger 24 may extend to drive the molten metal material 26 through the shot assembly 22 and out an opening through the front cover 44. The core 42 is sandwiched between the shoulder 68 of the front cover 44 and the rear cover 46 within the bore 34. Accordingly, the bore 34 may comprise a slip fit with the core 42 to ease removal.

[0039] A key 54 extends through the housing 28 and engages a surface of the core 42 to prevent rotation of the core 42 relative to the housing 28 and to maintain an alignment between the opening 52 of the core 42 and the opening 36 within the housing 28. The example key 54 comprises a threaded bolt that extends through the housing 28 and engages a flat surface 55 defined on the outer surface of the core 42. The flat surface 55 accommodates some longitudinal movement of the core 42 relative to the housing 28 as may occur due to differential thermal expansion during operation.

[0040] The housing 28 further includes an integral collar portion 38, including flats 40 that are utilized and provide for engagement of a tool. As appreciated, a tool can be utilized to engage the surfaces 40 to prevent rotation of the housing and thereby the shot sleeve 22 during tightening or loosening of the rear cover 46. Additionally, the example housing 28 does not include a mounting flange that requires larger starting stock material that is simply machined away to define a mounting flange.

[0041] Referring to Figure 5 with continued reference to Figures 2-4, the example shot sleeve 22 is installed within the mold assembly 10 and heated to a preheat temperature. The preheat temperature can range between 500°F and 2000 °F (260-1093 °C) and provides for heating the shot sleeve 22 to a temperature closer to that of the molten metal material to eliminate excessively quick rises of temperature.

[0042] The core 42 includes a thermal expansion coefficient schematically indicated at 64 that is much less than a thermal expansion coefficient of the housing 28 indicated at 62. Accordingly, once the shot sleeve 22 is heated to the preheat temperature; the housing 28 will become longer than the core 42. Because the housing 28 is longer than the core 42 a gap 60 may form between an end of housing 28 and the core 42. In this example, the gap 60 is defined between the shoulder 68 of the front cover 44 and an end of the core 42. Molten material poured within the bore 34 can become entrapped within the gap 60 and reduce effectiveness of the shot sleeve assembly 22. Accordingly, the core 42 is movable longitudinally in response to tightening of the rear cover 46. As appreciated, once the shot sleeve 22 is at the preheat temperature, the rear cover 46 is tightened such that it moves inwardly to push the core 42 forward against the shoulder 68 defined in the front cover 44. The rear cover 46 is then tightened to a defined torque to maintain the desired interface between the front end of the core 42 and the shoulder 68 of the front cover 44.

[0043] The molding operation can then proceed as indicated and described in Figure 1 where molten material 26 poured through the opening 36 into the bore 34 defined by the core 42. The plunger 24 is then pushed through the bore 34 to inject the molten material into the cavity 18.

[0044] Once molding has been completed, the shot sleeve 22 will cool to a much cooler temperature such as room temperature. At room temperature, the housing 28 will contract to a much larger degree than the core 42 thereby inducing stresses on the front cover 44 and the rear cover 46. Therefore, prior to cooling of the shot sleeve assembly 22, the rear cover 46 is loosened such that it moves longitudinally outward to provide additional space for the relative thermal contraction between the housing 28 and the core 42.

[0045] The example shot sleeve assembly 22 therefore includes modular components that can be replaced upon wear to reduce the expense of manufacture and accommodate relative thermal expansion between the core and the housing 28. The allowances provided by the example modular shot sleeve assembly 22 provide for the use of temperature compatible materials in locations where it is required while also providing for

the use of cheaper materials for the housing 28 to reduce costs and assembly. Additionally, the example shot sleeve assembly 22 provides a modular assembly that has the capability of preventing gaps between different thermally acting materials.

[0046] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the scope and content of this disclosure.

CLAIMS:

1. A shot sleeve assembly for a die casting process comprising:
 - a housing defining a bore open at both a front end and a rear end and a pour opening for receiving molten material, the housing comprising a material of a first coefficient of thermal expansion;
 - a core received within the bore and extending from the front end to the rear end including a core opening aligned with the pour opening, the core comprising a material of a second coefficient of thermal expansion lower than the first coefficient of thermal expansion;
 - a front cover attached to the front end of the housing; and
 - a rear cover attached to the rear end of the housing, the rear cover forcing the core against the front cover holding the core within the bore of the housing, wherein the rear cover comprises a nut threadingly received within the bore and rotatable to force the core against the front cover to maintain a desired interface between the front end of the core and a shoulder of the front cover.
2. The shot sleeve assembly as recited in claim 1, wherein the housing includes flats for holding rotation of the housing responsive to rotation of the rear cover.
4. The shot sleeve assembly as recited in claim 1, including a plurality of fasteners extending through the front cover for securing the front cover to the front end of the housing.
5. The shot sleeve assembly as recited in claim 4, wherein the front cover includes a plurality of threaded openings for receiving corresponding threaded fasteners for forcing the front cover from the housing.
6. The shot sleeve assembly as recited in claim 5, including a key member disposed between the housing and the core for holding a position of the core relative to the housing.
7. The shot sleeve assembly as recited in claim 6, wherein the core is fabricated from a refractory metal material.

8. The shot sleeve assembly as recited in claim 6, wherein the core is fabricated from a ceramic material.

9. A casting assembly comprising:

a mold including at least one cavity for receiving molten material;

a shot sleeve mounted to the mold for injecting molten material into the cavity, the shot sleeve including a housing defining a bore open at both a front end and a rear end and a pour opening for receiving molten material, the housing comprising a material of a first coefficient of thermal expansion, a core received within the bore and extending from the front end to the rear end including a core opening aligned with the pour opening, the core comprising a material of a second coefficient of thermal expansion lower than the first coefficient of thermal expansion, a front cover attached to the front end of the housing, and a rear cover attached to the rear end of the housing, the rear cover forcing the core against the front cover holding the core within the bore of the housing, wherein the rear cover comprises a nut threadingly received within the bore and rotatable to force the core against the front cover to maintain a desired interface between the front end of the core and a shoulder of the front cover; and

a plunger movable through the bore of the shot sleeve for forcing molten material through the core and into the at least one cavity.

10. The casting assembly as recited in claim 9, wherein the front cover includes a shoulder against which the core abuts for holding the core within the bore.

11. The casting assembly as recited in claim 10, including a key member disposed between the housing and the core for holding a position of the core relative to the housing.